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Digital Mapping, Charting, and Geodesy Analysis Program Technical Review of Urban Vector Smart Map (UV_{Map}) Prototype 1

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In an effort to transition from paper to digital maps, the Defense Mapping Agency (DMA) has produced several prototypes that will be used throughout the military (and final products will likely be used in civilian environments). Some examples are the Digital Chart of the World and World Vector Shoreline. As part of the prototyping procedure, DMA via N096 regularly requests the Naval Research Laboratory's Digital Mapping, Charting, and Geodesy Analysis Program for evaluations of the prototypes. Described in this report are the results of the evaluation of one such prototype: Urban Vector Smart Map (UV_{Map}). Digitized from city graphics and stored on Compact Disk-Read Only Memory, UV_{Map} shows potential as being an excellent source of high-resolution, easily accessible (under proper classification restraints) urban data. Implementation of the suggestions will enhance UV_{Map}'s capabilities.

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1.0 Introduction

The following review of Urban Vector Smart Map (UV_{Map}) is based on the implementation of the Havana, Cuba city graphics, sheets 1-4. Supporting the Vector Product Format (VPF), UV_{Map}'s implementation and product specification [1] have several issues that need to be addressed in order to maximize its potential as a useful product.

The noted errors and suggested changes are presented here in three broad, sometimes overlapping areas: product specification, implementation, and disagreements between the two. The methodology for evaluation and reasons for derived conclusions are presented in each of the sections. The final section summarizes the comments and suggestions for changing the UV_{Map} prototype.

2.0 Product Specification

2.1 UV_{Map} Content. UV_{Map} allows for 2 coverages at the library level and 10 coverages at the thematic coverage level:

Library Coverage	• Library Reference • Tile Reference	
Thematic Coverage	• Boundaries • Data Quality • Elevation • Hydrography • Industry	• Physiography • Population • Transportation • Utilities • Vegetation

Data Quality coverage, its purpose, and the information contained therein should be re-evaluated. This discussion will be presented in the implementation section (Sec. 2.3).

2.2 Modeling and Simulation Requirements. To assist the Defense Modeling and Simulation Office and the Defense Mapping Agency in determining specific modeling and simulation (M&S) requirements, the Digital Mapping, Charting, and Geodesy Analysis Program (DMAP) conducted a survey in which current and future requirements of the Navy and Marine Corps M&S community were analyzed. The specific needs of 110 survey respondents were evaluated, and the requirements were compared to upcoming VPF product specifications, one of which was UV_{Map}. Table 1 presents those features and attributes, stated as requirements for the modeling and simulation community, were not included in UV_{Map} Prototype 1.

As can be seen, Hydrography and Physiography are the coverages that are the most deficient in the area of M&S features. A significant disparity between the UV_{Map} product specification and the survey requirements exists in the level of detail (i.e., number of attributes) of the features. However, the practicality of implementing such high detail is questionable, due to the rapid and unpredictable fluctuation of urban data over short time periods. Matters of updating must be considered (see Sec. 3.4).

Among those programs having M&S feature and attribute requirements, 11 participating programs indicated a strong necessity for an urban area database. The requirements of these programs spanned every thematic coverage of UV_{Map}. A table of these specific requirements, together with related accuracy and resolution measurements, is given in Table 2. Although most of the features listed in Table 2 are included in UV_{Map}, the accuracy and resolution requirements for each coverage would be difficult to meet under the current procedure of digitizing paper charts for UV_{Map} data. The source charts currently determine these values.

In any case, DMAP recommends adding to UV_{Map} each feature and attribute requirement in Table 1. Provisions should be made to meet the finer feature details on an as needed basis, possibly as additional layers. Moreover, based on the results of the survey, the following changes should be incorporated:

- In Population (note, Table 1 survey findings used a populated place to describe this type of data), add to Buildings (AL015) the attribute Structure Shape of Roof.

- In Population, add to Built-Up Area (AL020) the attribute Density Measure, percent of roof cover.

- According to [1], PPL (Populated Place Category), used as an attribute for Built-Up Area (AL020) in the Population coverage, should receive an actual numeric value. In the UV_{Map} specification, PPL instead receives attribute values corresponding to classes. The specification should describe the class limits or give the actual population. The date (attribute DAT) would be an ideal addition to fully describe these feature classes.

- To the Ground Surface Element (DA010) MCC (Material Composition Category) in Physiography the value 84 (Rock/Rocky) should be added.

- In Transportation, add to Bridge/Overpass/Viaduct (AQ040) the Bridge/Bridge Superstructure Category value 7 (Tower Suspension). Also add the attribute Bridge Span Mobility, including the value 1 (Moveable Span).

- Add Depot (Storage) (AM010) to the Transportation coverage, with USE (Usage) attribute including the value 119 (Berthing of Vessels).

- Add the attribute Road Interchange Type to Interchange (AP020) in the Transportation coverage.

2.3 Data Quality. The manner in which the data quality in UV_{Map} is recorded will present a deficiency to the average UV_{Map} user. Typically, with regard to data quality, the user will be interested in making specific judgements from the information provided. General statements will not assist in this effort.

One problem (particularly with the Havana implementation) is the lack of Data Quality feature classes in the thematic coverages. In order to be useful, data quality must be specific to individual features, and it must be quantitative to the maximum extent possible. Data quality values do not have to be numerical, but they do have to be specific and clearly defined. Attaching a text string of "Approximate" to all features in a given area, as the UV_{Map} specification presently allows, is not specific nor does "Approximate" have a clear definition. Also, Data Quality in the present structure does not include the likelihood of the existence of a given feature. This existence measure of a feature is defined in a separate attribute.

According to the product specifications, Data Quality in UV_{Map} may consist of four separate sets of tables and attributes:

1. The library level Data Quality Table (DQT)
2. The Data Quality Coverage
3. Data Quality feature classes in thematic coverages
4. Data Quality attributes in individual feature tables

Each UV_{Map} library defines the absolute horizontal and vertical data accuracies that apply to the entire library and records this information in the DQT. The UV_{Map} specification defines the absolute horizontal accuracy as one standard deviation of the random error (page 5 of [1]). If this number is meaningful, then it implies that approximately one-third of the features in a UV_{Map} database exceed the specified absolute horizontal accuracy. Applying such a general number to the entire library is difficult, since the absolute horizontal accuracy of a radio tower is likely to be different than the absolute horizontal accuracy of a grove of trees. The DQT in the UV_{Map} of Havana, for example, has limited useful information. Also, the entries in the table for the various accuracies (entries such as Unknown, Undefined, and Meters) are incorrect: the word "Meters" is recorded in the location reserved for the numeric values, and the field titled ABS_VERT_UNITS, the location for the units, is marked as "Undefined."

The Data Quality Coverage is intended primarily to describe the steps taken to reduce or ameliorate an edge mapping problem between source sheet maps. This coverage does not refer to the accuracies of feature classes, features, or feature instances in the interior of a sheet map. If there are no edge mapping problems, this coverage will not appear, as is apparently the case with the Havana implementation.

The Data Quality feature classes in thematic coverages consist of five optional tables, the Data Quality Point Feature Table, the Data Quality Node Feature Table, the Data Quality Line Feature Table, the Data Quality Area Feature Table, and the Data Quality Text Feature Table. These tables have at most references linking a given point, line, area, or text feature classes to a central

table of data quality descriptors, text strings describing the quality of the feature. No provision is made to record the Data Quality of an individual feature instance. For example, a coverage may contain many instances of cisterns (BI010), but none of the DQTs can refer to a specific instance of a cistern, only to the aggregate of cisterns. This type of documentation, although much more difficult to incorporate than the "aggregate" type, would be an ideal quality of UV_{Map}.

UV_{Map} has defined data quality attributes for eight of the features. These data quality attributes (ACC) attached to specific features are useful but only defined for a small fraction of features in the database. The formal definition of the terms used in these attributes (terms like Accurate and Approximate) should be defined in the specification.

In summary, using the data quality information in UV_{Map} is difficult because of the multiple locations where the information might be stored. The potential ambiguity of having multiple differing definitions of accuracy for a given feature makes successfully estimating the accuracy and quality of specific feature instance difficult or impossible.

To reduce some of the confusion associated with data quality, the UV_{Map} specification should be modified as follows:

• The specification should define data quality terms so that the terminology in each database is well defined and consistent; e.g., "Approximate" means "within X meters," etc.

• The specification should define attributes for relative horizontal and absolute vertical accuracy for each feature class (in DQPOINT.PFT, DQNODE.PFT, DQLINE.LFT, etc.). If numerical definitions of accuracy are made, then the standard definition of the term relative accuracy is the position of a given feature to within +/- n meters measured from any other feature within a radius of m meters.

• A single method (specific to each feature class) for recording data quality measurements should be included in the specification.

• The specification should discuss the effects on data accuracy when different data sets are in different coverages. The VPF specification states that topology is not preserved between coverages, but what that means in terms of relative and absolute accuracy is not discussed.

• The Data Quality Coverage should be renamed to Edge Quality Coverage (or some other appropriate name) to more accurately describe the purpose of the coverage. This coverage refers only to a limited subset of the data quality of a library.

2.4 General Errors and Suggestions. Obvious errors exist in the written specification. Suggested corrections are detailed below. Also included are recommendations that would make UV_{Map} more robust and useful. Adopting such changes, however, could result in a modification to the VPF.

• There are items in the specification marked "TBD" ("To Be Determined," e.g., on page 28) and "TBR" ("To Be Resolved," e.g., on page 5). These should be completed before any further development of UV_{Map}. Also, an index should be added to the specification.

• Many references to the now obsolete (for VPF purposes) FACS still exist; e.g., on page 7 and page 29. Also, MIL-STD-600000, referenced on page 3, uses the FACS coding scheme. Other than feature/attribute definitions, this document appears to serve no purpose in the UV_{Map} product specification. In brief, any mention of FACS should be removed, except possibly for historical purposes.

• The vertical accuracy section (3.1.2) is vague. Examples would be helpful.

• The figures in the specification are descriptive and clarify the text. These should be used in any instances where facts are better conveyed by a figure.

• A diagram showing all table types and their interactions should be included.

• A list of features and attributes, without reference to tables, primitives, codes, etc., should be included. This list should contain only layman's terms (e.g., hydrography, road, trees, etc.).

• Regarding Sec. 3.1.3, the user should have some indication of which features are subject to displacement.

• Some attributes are extraneous for the particular feature they describe. For example, the Rig/Well point feature lists the attributes Spring/Well Characteristic Category and Well/Spring Type for the feature Oil Well (AA050), both of which have only two valid values: Unknown and Not Applicable. If no useful information can be provided by these attributes, they should be eliminated.

• Both "Null" and "Not Applicable" are often used interchangeably in the specification. These occurrences should be changed to "Not Applicable" for any attribute that does not apply to a particular feature. The subtle distinction between the two, if any, is not worth the confusion that results. If there is intent for these terms to have different meanings, then an additional definition is needed.

• The addition of an optional general comment text field, similar to that contained in the Digital Nautical Chart (DNC), at the attribute level should be considered. This field would be implemented to handle special cases including data quality exceptions, points of special interest, and feature instances for which the given attributes cannot adequately describe. This field could also serve as a user comment area to be used for application specific data without resorting to overlays or externally referenced fields.

• The Hydrography coverage should contain coastal zone bathymetry for cities fronting major bodies of water.

• Contour lines in the Elevation coverage should be labeled. As UV_{Map} stands, to ascertain the meaning of a particular contour line a query must be made of that line. A Text Feature Class should be added.

• The usefulness of UV_{Map} is crippled by the lack of a standard symbology set coupled to default feature color codes. When attempting to view a selected group of features, the ability to quickly draw a standard map would be a valuable asset. The ability to produce custom views is essential to the versatility of the product, but the option of not being required to do so would be a great improvement.

• The feature class Elevation point has the attribute MCC with possible values of Unknown and Earthen, which is rather limited since an elevation point is either a topographic point (e.g., earth or rock) or it is some specific object, such as a tower or tree. More codes should be added from [2] to accurately define Elevation points.

• A measure of depression, other than merely an indication of it, should be provided in the Elevation layer. At present, only positive values are used in the attribute ZV1 (Z value above datum) of Spot Elevation (CA030) and Contour (Land) (CA010). These should be changed to include nonpositive measurements.

• The feature class BRIDGEL.LFT should have the attribute Bypass Condition Category. This attribute is a prime example of information that can be used to make practical decisions regarding a given feature, in this case a bridge.

3.0 Implementation of Havana City Graphics (four sheets)

3.1 Missing Coverages. This particular implementation is lacking the two Library Coverages (Library Reference and Tile Reference), which normally appear as Coverage options in the Feature Selection window of VPFVIEW. Also missing is the Data Quality thematic coverage. While some thematic coverages may be optional, Data Quality, or at least some easily accessible information regarding data quality, should always be included.

3.2 Limits of Primitive Classes. No reference is made as to how future digital modifications, additions, and updates will be performed on these products.

More specifically, the specification, as well as the Havana implementation do not provide established rules as to what attributes determine a feature's primitive type. For instance, a road may be represented as an area feature or a line feature, as evidenced by the Havana Transportation coverage. Currently the deciding factor as to which primitive the road is classified is width of the road on the source paper chart. In the future, when a road is added to a database via a strictly digital update, some width limits will have to be known in order to determine the primitive class, since a paper chart may not be available. Rivers, dams, runways, and taxiways are other VPF features that follow a similar structure.

To alleviate confusion, a detailed explanation, including those attributes and values determining the primitive class of a feature, should be included in the product specification.

3.3 General Errors. The following problems were noted in examining the Havana dataset:

• Only one discrepancy has been detected in comparing the Havana city graphics with the digital version. Figure 1 displays a river/stream (EDGE 215) in the database that does not appear in the source charts. This could be a digitizing error or an update to the actual city graphic. If EDGE 215 is an update from the chart, this fact should be indicated.

• The entries in the DQT for the various accuracies (entries such as "Unknown," "Undefined," and numeric values in Meters) are incorrect: The word "Meters" is recorded in the location reserved for the numeric values, and the field titled ABS_VERT_UNITS, the location for the units, is marked as "Undefined."

• The Library Header Table lists the source (city graphics) as an unclassified medium; whereas, the Havana city graphics are classified SECRET. If an intermediate source, downgraded to unclassified, was used, this fact should be indicated.

• On the original paper charts, a small scale version of the map, showing city and provincial limits, was included in the lower corner; no indication of this information was present in the Havana UV_{Map} implementation.

3.4 Medium Compact Disk-Read Only Memory (CD-ROM) and Updating. Since UV_{Map} is planned for release on CD-ROM, special considerations must be given to the process by which updates are made. Urban features are constantly changing, which means that any database containing urban data should be subjected to many updates. CD-ROM, however, doesn't immediately allow for changes.

DMAP recommends the continued development of the MC&G Utility Software Environment (MUSE) software to include editing facilities for vector products. These facilities would include the ability to add to or change specific entries in the database, as well as annotation and overlay capabilities, once the database is transferred to a writable medium. The ability to mark points of interest, routes followed, or to make corrections would be useful when working with a database which, by its very nature, should be constantly updated.

4.0 Implementation vs. Product Specification

Discussed in this section are the discrepancies between the implementation of the Havana city graphic sheets into UV_{Map} and the written product specification. For such a comparison, the VPFVIEW software was used, as well as VPFDUMP, which allowed for a more thorough evaluation. Most disagreements between implementation and specification are a result of attribute values being omitted from the specification, while being included in the database. Also, the

VPFVIEW data dictionary option, when accessed from the VPF Contents button of the VPFVIEW window, does not present a true set of attribute values for the UV_{Map} database.

4.1 Missing Attribute Values. Appendix A presents, by coverage, a detailed listing of attribute values that are missing from the specification but occur at least once in the database. These values were determined by an intensive examination of the point, line, and area feature tables in each thematic coverage. Created by VPFDUMP, the tables were transferred to hard copy for evaluation. For the larger tables such as the road line table, only a selection of the beginning features were evaluated. All relevant information (e.g., tile ID and primitive ID) is given for ease of specific database location.

The recommended solution is to include the missing attribute values (Appendix A) in the specification rather than removing the extraneous values from the database.

4.2 Data Dictionary Attribute Values. The Data Dictionary option under VPF Contents supplies on-line information about the attributes and their respective values in a given database. For the UV_{Map} Havana database, however, all values displayed in the Data Dictionary are either 0 or those values indicating "null," such as -9. Clearly, a problem exists here, as can be proven by performing a spatial query on practically any feature, which almost always yields valid attribute values (see exceptions in Appendix A). This problem suggests a discrepancy between product specification and database, since the values simply do not match.

Upon further investigation, the problem was discovered to occur in other VPF databases such as V_{Map}. Thus, either VPFVIEW is processing the VPF incorrectly, or the VPF including the UV_{Map} implementation is incorrect.

Since the on-line aspect of the Data Dictionary is a valuable asset, the problem should be investigated before any additional VPF prototypes (including UV_{Map}) are produced.

5.0 Problems Relating to VPFVIEW

• The VPFVIEW spatial query handles the cases of questionable attribute values in an inconsistent manner. For example, on Process Area FAC_ID 212, TILE_ID 2, the Product Category PRO is 21, and the spatial query shows this value with no parenthetical description. "Concrete" would be the correct expression. In contrast, Storage Point NODE_ID 108, TILE_ID 2 has a location category LOC value of 25, meaning "Suspended or Elevated above Ground or Water." This description is displayed parenthetically onscreen during spatial query, although 25, similar to the PRO value 21, is not an attribute value listed in the specification.

• LINEAGE.DOC is not readable under the VPF Contents option of VPFVIEW.

• To maintain spatial query consistency across all features in a class, attributes, which have an unknown or not applicable value, should be displayed as such in VPFVIEW. By omitting an

attribute field, VPFVIEW misleads the user. The Road Line feature class in the Transportation coverage demonstrates the confusion by not displaying the name attribute when a name is unknown. NAM followed by a blank character string or the term "Unknown" would be preferable.

• To enhance UV_{Map} potential as a source for Geographic Information System (GIS) applications, VPFVIEW should allow the user to select an area (zoom/pan, etc.) and draw all features from *each* coverage, rather than the time-consuming manual selection of the "All" option in each coverage. Having this feature would eliminate doubts of incomplete data (e.g., apparent broken water course lines that are actually filled in with water course areas, etc.).

6.0 Conclusions and Recommendations

Enumerated below are summaries of DMAP's major suggestions for improving the UV_{Map} prototype.

1. A fundamental problem, relating to UV_{Map}'s potential usefulness in GIS applications, is its inability to recognize complete objects when more than one feature comprises that object. Figure 1 demonstrates this phenomenon. Several water course lines appear to be broken, to the point that the average user could wrongly conclude that dry land was present between the water courses. In this particular view, however, some of the breaks are filled-in when aqueducts are displayed.

2. The Data Quality coverage, its purpose, and the information contained therein should be completely re-evaluated. In fact, due to multiple locations of what is termed "data quality," all aspects of data quality recording should be re-evaluated, including LINEAGE.DOC. Some specifics to address are definitions for data quality terms (e.g., "Approximate"), methods for recording data quality, and the measurement of horizontal accuracy.

3. A standard symbology set is required for UV_{Map}.

4. The Modeling and Simulation requirements (features and attributes listed in Table 1) should be incorporated into UV_{Map}. Attributes and specific values listed in Sec. 2.2 should also be added.

5. The attribute values listed in Appendix A should be added to the product specification.

6. Guidelines should be established for determining the primitive type of a particular feature, both for paper charts and digital updates.

7. MUSE software should be developed to work in conjunction with UV_{Map} and other VPF products.

7.0 Acknowledgments

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8.0 References

[1] Defense Mapping Agency, *UV_{Map} Product Specification (draft)*, May 1993.

[2] Defense Mapping Agency, *The Digital Geographic Information Exchange Standard (DIGEST) Part 4: Feature and Attribute Coding Catalog (FACC)*, Edition 1.1, October 1992.

Table 1. Current and Future Requirements not met by UV_{Map} Prototype 1 Product Specification dated May 1993 (derived from DMAP 1993 survey).

Key: **Current Requirement Only**
Current and Future Requirement
Future Requirement Only

FEATURE CLASS	FEATURES	ATTRIBUTES
ELEVATION	Depth Contour, Slope Polygon, Depression, Berm/Barricade, Ridge Line, Shaded Relief, Benchmark	Lineage, Location, Min/Max/Medial Elevation, **Standard Deviation**, Root Mean Square Variability, Radar Reflectivity, Emissivity, **Albedo**
TRANSPORTATION	Culvert, RR Turntable, Tramway/ Incline Railway, Distance Marker, Route Marker, Rest/Vehicle Stopping Area, Vehicle Storage/Vehicle Parking, Dragon (Tiger) Teeth, Anchorage, Snowshed /Rock Shed, Fueling Areas, Digital Feature Analysis Data **(DFAD) Features**	Substructure Description (spans), Lineage, **DFAD Attributes, Miles Covered (span, distance)**, Radar Reflectivity, Emissivity, Infrared (IR) & Night Vision Goggles (NVG), Albedo, Flight Information Publication (FLIP)/Digital Aeronautical Flight Information File (DAFIF) information for Air Facilities, *Location*
VEGETATION	Bog, Open/Meadow/Pasture, Coral Reef, Shrub, Sea Growth, DFAD features	Radar Reflectivity, Summer percent Density, Winter percent Density, **Emissivity**, IR & NVG, Albedo, **DFAD Attributes**, *Radio Frequency, Electro-Optical Reflectivity*
HYDROGRAPHY	Waterfall, Sounding, Piling, Rock, Wreck, Underwater Cable, Shipping Channel, Inland Channel, Rapids, Tunnel/Bridge, Spoil/ Disposal Area, Gridiron, Offshore Loading Facility, Maritime Station, Buoy, Electronic Beacon, Light/ Lighthouse, Crib, Breaker, Anchorage Area, Pier, Reef, Wharf Area, Ship Repair Area/Dry Dock, Bottom Sample, Misc. Underwater Feature, **Surf, DFAD Features, Smoke**, *Standard Worldwide Harbor Data, Shallow-Water Features: ground surface, rock formation, cave, sand dunes/hills*	Left Bank Delineation, Right Bank Delineation, Left Bank Slope, Right Bank Slope, Subsurface Material, Velocity, Lineage, Location, **DFAD Attributes**, Riverine attributes, Radar Reflectivity, Emissivity, Albedo

FEATURE CLASS	FEATURES	ATTRIBUTES
POPULATED PLACE		Roof Type, Surface Material, Density of Roof Cover, Entrance /Exit, Window - Specific, Window - General, Interior Floor Plan, Address, Occupant, Height Accuracy, Lineage, Population, Location, Building Traits, Radar Reflectivity, Emissivity, IR & NVG, Albedo, *Cross Section Areas, Size of Ext. Walls of Large Buildings*
INDUSTRY	Flare Pipe, Windmill/Wind Motor, Blast Furnace	Roof Type, Surface Material, Density of Roof Cover, Entrance/Exit, Window-Specific, Window-General, Interior Floor Plan, Name, Address, Occupant, Type of Processing Industry, Location, Radar Reflectivity, Emissivity, IR & NVG, Albedo, Methods Used (nets, traps, etc.), *Cross Section Areas*
SOIL	Gravel, Sand, Silt, Clay, Peat, Evaporites, Rock Outcrops, Plain Dirt, Rocky Terrain, *Beach*	Grade, Soil Depth, State of Ground, Trafficability, **Roughness**, Material Composition, Confidence of Interpretation, Lineage, Ground Wetness, **Surface Roughness**, Acoustic/Magnetic/Pressure properties, **Layer Description**, Radar Reflectivity, Emissivity, IR & NVG, Albedo, *Thermal Mass/Conductance, Radio Frequency*
PHYSIOGRAPHY	Berm/Barricade, Mountain Pass, Rock Formation, Crevice/Crevasse, Cave, Glacial Moraine, Esker, Geothermal Feature, Glacier, Ice Cliff, Ice Peak/Nunatak, Ice Shelf, Pack Ice, Polar Ice, Snow/Ice Field, Volcano, Void Collection Area, Lava Flow, Ridge Line, **Shallow-Water Features: ground surface, rock formation**	Height Accuracy, Lineage, Thickness, Material Composition, Age, Width, Location, Radar Reflectivity, Emissivity, IR & NVG, Albedo, **Acoustic/Magnetic/Pressure properties**
UTILITY	Communication Node, Condensation Line, Sanitary Sewer, Steam Line, Telephone Station, *Dam*	Number of Cables in Conduit, Kilo Volt Ampere (KVA), Radar Reflectivity, Emissivity, IR & NVG, Albedo, *Probability to Kill, Radar Cross Section*

FEATURE CLASS	FEATURES	ATTRIBUTES
BOUNDARY	De Facto Boundary, Boundary Marker, Armistice Line, Cease-fire Line, Cairn, Restricted Airspace, Demilitarized Zone, Software Boundary, Key Tracking Area, Low Intensity Conflict Area, Sensitivity Area	Length, Width, Height Above Ground, Surface Material, Height Accuracy, Location, Controller of Boundary, Boundary Conditions (i.e., barbed-wire fence), Radar Reflectivity, Emissivity, Albedo, Acoustic/Magnetic/Pressure properties, *IR & NVG*

Table 2. Urban Area Database Requirements Derived from DMAP 1993 Survey.

FEATURE CLASS	FEATURES	ACCURACY (meters) (range, mode)	RESOLUTION (meters) (range, mode)
ELEVATION	Land Contour, Regular Spaced Grid, Triangular Irregular Network, Spot Elevation	Abs Hz: 0.5 - 25 Mode: 5 Rel Hz: 0.05 - 2.5 Mode: 0.5 Abs Vert: 0.05 - 125 Mode: 1 Rel Vert: 0.05 - 125 Mode: 0.5	Hz: 1 - 125 Mode: 1 Vert: 3 - 125 Mode: 3
TRANSPORTATION	Road, Trail, Interchange, Bridge/ Overpass/Viaduct, Culvert, Tunnel, Ramp, Ford, RR Track, RR Siding/Spur, RR Turntable, RR Yard, Tramway/Incline Railway, Control Tower, Distance Marker, Route Marker, Vehicle Storage/Vehicle Parking, Dragon (Tiger) Teeth, Aircraft Facility, Aircraft Facility Beacon, Overrun /Stopway, Ferry Crossing, Mooring Mast, Anchorage, Dry Dock, Pier/Wharf, Lighthouse	Abs Hz: 1 - 10 Mode: 5 Rel Hz: 0.5 - 2.5 Mode: 2.5 Abs Vert: 0.25 - 25 Mode: 1 Rel Vert: 0.05 - 25 Mode: 0.5	Hz: 1 - 25 Mode: 1 Vert: 3 - 15 Mode: 3
VEGETATION	Trees, Cropland, Hedge Row, Nursery, Orchard/Plantation, Vineyard/Hops, Grassland, Scrub/ Brush, Bamboo/Cane, Firebreak/ Cleared Way, Oasis, Tundra, Bog, Hummock, Swamp, Marsh, Open/Meadow/Pasture	Abs Hz: 1 - 25 Rel Hz: 0.5 - 5 Mode: 5 Abs Vert: 0.05 - 125 Mode: 1, 2.5 Rel Vert: 0.05 - 125 Mode: 0.5, 1, 2.5, 10	Hz: 1 - 125 Mode: 1, 1.5 Vert: 3 - 125 Mode: 3

FEATURE CLASS	FEATURES	ACCURACY (meters) (range, mode)	RESOLUTION (meters) (range, mode)
HYDROGRAPHY	River, Stream, Waterfall, Lake/ Pond, Spring/Water Hole, Lock, Aqueduct, Canal, Ditch, Inundation/Flood Area, Reservoir, Shoreline, Sounding, Open Water, Breakwater, Jetty, Seawall, Piling, Rock, Wreck, Underwater Cable, Shipping Channel, Inland Channel, Rapids, Current/Flow Arrow, Tunnel/Bridge, Water Tower, Spoil/Disposal Area, Offshore Loading Facility, Electronic Beacon, Light/ Lighthouse, Breaker, Pier, Reef, Wharf Area, Ship Repair Area/ Dry Dock, Sluice Gate, Bottom Sample, Misc. Underwater Feature	Abs Hz: 0.5 - 15 Mode: 5, 10, 15 Rel Hz: 0.5 - 2.5 Mode: 2.5 Abs Vert: 0.05 - 125 Mode: 1 Rel Vert: 0.05 - 125 Mode: 1	Hz: 1 - 125 Mode: 1 Vert: 3 - 125 Mode: 3, 15
POPULATED PLACE	Building, Built-up Area, Fort, Plaza/City Square, Park, Religious Shrine/Mosque, Tent Dwelling, Underground Dwelling, Trailer Park, Cemetery, Athletic Field, Fairgrounds, Amusement Park, Outdoor Theater/ Amphitheater, Golf Course, Stadium, Monument, Ruins	Abs Hz: 1 - 15 Mode: 1, 15 Rel Hz: 0.25 - 25 Abs Vert: 1 - 25 Rel Vert: 0.05 - 25 Mode: 25	Hz: 1 - 25 Mode: 1 Vert: 3 - 100 Mode: 3
INDUSTRY	Processing/Treatment Plant, Chimney/Smokestack, Cooling Tower, Tower (non-communication), Disposal Site/ Waste Pile, Wrecking/Scrap Yard, Catalytic Cracker, Settling Basin/Sludge Pond, Conveyor, Crane, Flare Pipe, Tank, Water Tower, Nuclear Accelerator, Windmill/Wind Motor, Feedlot/ Stockyard/Holding Pen, Grain Bin, Grain Elevator, Silo, Storage Bunker/Mound, Mine, Quarry, Filtration/Aeration Bed, Fish Hatchery, Flume, Salt Evaporator, Cistern, Blast Furnace	Abs Hz: 1 - 15 Mode: 1, 15 Rel Hz: 0.25 - 10 Mode: 10 Abs Vert: 1 - 25 Rel Vert: 0.05 - 25 Mode: 25	Hz: 1 - 25 Mode: 1 Vert: 3 - 100 Mode: 3

FEATURE CLASS	FEATURES	ACCURACY (meters) (range, mode)	RESOLUTION (meters) (range, mode)
SOIL	Gravel, Sand, Silt, Clay, Peat, Evaporites, Rock Outcrops	Abs Hz: 0.5 - 25 Mode: 1 Rel Hz: 0.25 - 5 Mode: 2.5 Abs Vert: 0.05 - 125 Mode: 2.5 Rel Vert: 0.05 - 125 Mode: 0.5, 1, 2.5	Hz: 1 - 125 Mode: 3 Vert: 3 - 125 Mode: 3, 6
PHYSIOGRAPHY	Ground Surface, Island, Mountain Pass, Rock Formation, Bluff/ Cliff/Escarpment, Crevice/ Crevasse, Glacial Moraine, Asphalt Lake, Salt Pan, Embankment, Fault, Geothermal Feature, Sand Dunes/Hills, Glacier, Snow/Ice Field, Sabkha, Volcano	Abs Hz: 1 - 25 Mode: 15 Rel Hz: 0.25 - 2.5 Mode: 2.5 Abs Vert: 0.05 - 5 Mode: 1, 2.5 Rel Vert: 0.05 - 5 Mode: 0.5, 2.5	Hz: 1 - 50 Mode: 1, 1.5 Vert: 3 - 50 Mode: 3
UTILITY	Power Plant, Water Treatment Plant, Substation/Transformer Yard, Pumping Station, Station (communication), Pipeline/Pipe, Power Transmission Line, Dish, Telephone/Telegraph Line, Utility Line (water/gas/sewer), Tower (communication), Underground Pipeline, Solar Panel	Abs Hz: 0.5 - 10 Mode: 1 Rel Hz: 0.25 - 2.5 Mode: 0.25, 1 Abs Vert: 0.05 - 25 Mode: 1 Rel Vert: 0.05 - 25 Mode: 0.25, 0.5, 1, 2.5	Hz: 1 - 25 Mode: 1 Vert: 3 - 15 Mode: 3
BOUNDARY	Administrative Boundary, De Facto Boundary, Boundary Marker, Coastal Shoreline, International Date Line, Armistice Line, Cease-fire Line, Wall, Fence, Cairn, Control Point	Abs Hz: 1 - 10 Mode: 1, 5 Rel Hz: 0.5 - 2.5 Mode: 0.5 Abs Vert: 0.05 - 125 Mode: 1 Rel Vert: 0.05 - 125 Mode: 1	Hz: 1 - 125 Mode: 1.5 Vert: 3 - 125 Mode: 3

Survey Identification Numbers: 010, 052, 053, 062, 075, 076, 088, 092, 102, 103, 106

010 Title: CVWST (Carrier Weapon Systems Trainer), AH1W, SH60B/F, AV-8B, F/A-18
POC: Mr. Steve Hollis
NTSC 251
(407) 380-8479960-8479

052 Title: Multiple Facilities Management and Construction Projects
POC: Ms. Karol Scott
NCEL
(805) 982-1677551-1677

053 Title: Crisis Response
POC: Ms. Karol Scott
NCEL
(805) 982-1677551-1677

062 Title: Analysts Work Bench
POC: Mr. Curt Danhauser
NAWC Weapons Div, China Lake C024304

075 Title: General Marine Corps MC&G Support
POC: CWO-2 J.J. Schwartz
2D Topographic Platoon
(919) 451-3969484-2926

076 Title: NPS Net Project
POC: Dr. Michael Zyda
Naval Postgraduate School CS/ZK

088 Title: Generic Marine Corps dMC&G Requirements
POC: Mr. Kurt Savoie
MARCORSYSCOM
(703) 640-4525278-4525

092 Title: Life Cycle Facilities Management Information Systems
POC: Ms. Karol Scott
NCEL
(805) 982-1677551-1677

102 Title: Team Target Engagement
POC: CWO-2 J.J. Schwartz
2D Topographic Platoon, USMC
(919) 451-3969484-2926

103 Title: Targeting and Fire Control
POC: Mr. Al Sutton
NAWC Weapons Div, China Lake C21501

106 Title: MTWS (Marine Air-Ground Task Force Tactical Warfare Simulation)
POC: MAJ P.D. Connally
MARCORSYSCOM C2G
(703) 640-3351278-3351

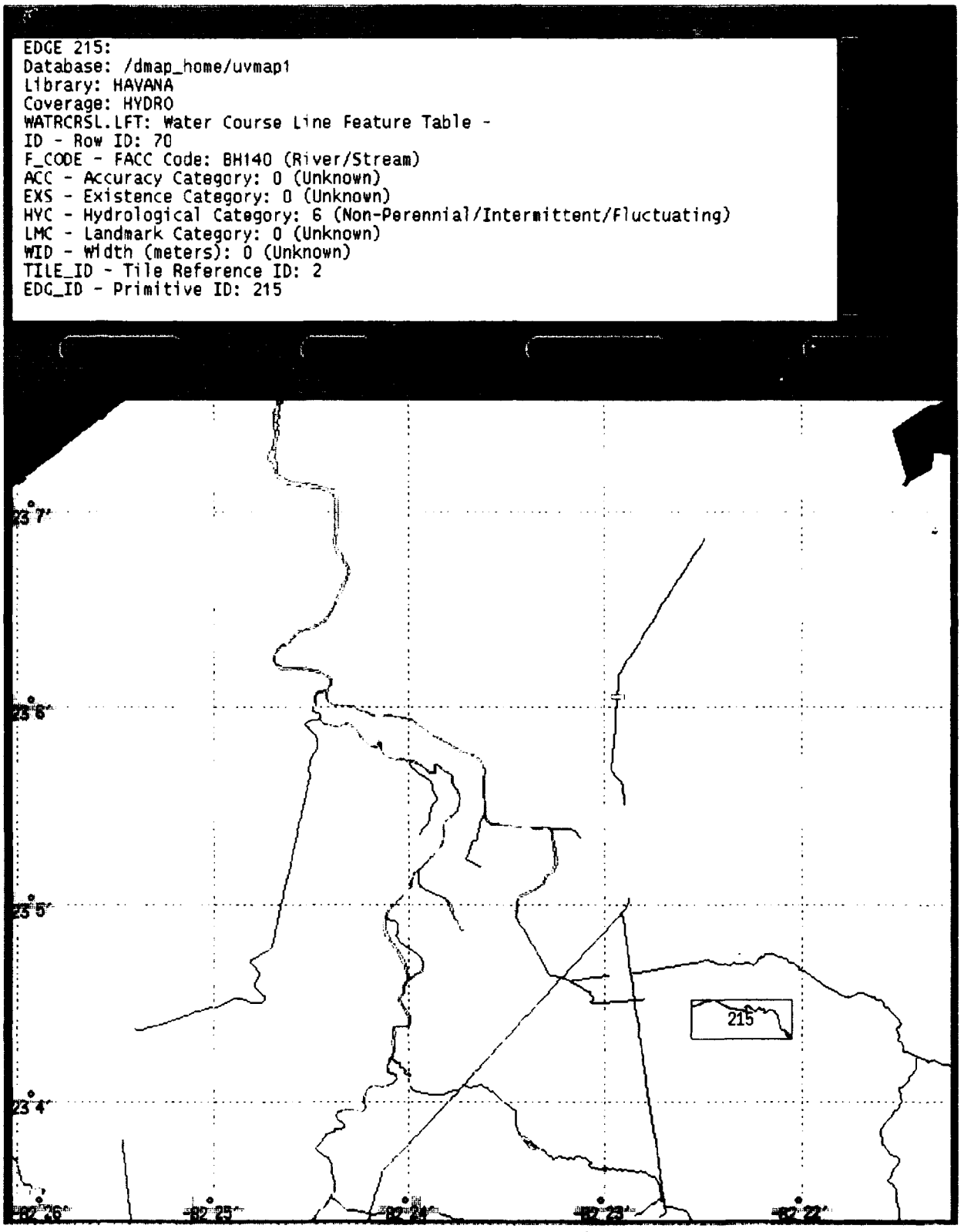

Figure 1. Possible digitizing error / Water courses showing "broken" lines.

Appendix A. Attribute Values Missing from the Product Specification.

COVERAGE	FEATURE TABLE	ID NUMBER	F_CODE	MISSING ITEM*	TILE	PRIM. ID
Population	Complex Area	10	AL045	BFC 81	2	979
Population	Complex Area	16	AL045	PRO 56	2	1294
Population	Complex Area	17	AL045	PRO 56	2	1296
Population	Complex Area	70	AL045	BFC 51	3	243
Population	Complex Area	72	AL045	BFC 51	3	249
Population	Complex Area	73	AL045	BFC 51	3	252
Population	Complex Area	92	AL045	BFC 55	3	671
Industry	Obstruction Point	105-117	AL240	TTC 4	2	235-247
Industry	Process Area	5	AC000	PRO 35	2	178
Industry	Process Area	7	AC000	PRO 21	2	212
Industry	Process Area	11	AC000	PRO 35	2	224
Industry	Process Area	12	AC000	PRO 17	2	225
Industry	Process Area	18	AC000	PRO 35	2	250
Industry	Process Area	20	AC000	PRO 35	2	256
Industry	Process Area	24	AC000	PRO 35	2	273
Industry	Process Area	25	AC000	PRO 103	2	274
Industry	Process Area	26	AC000	PRO 74	2	276
Industry	Process Area	28	AC000	PRO 35	2	278
Industry	Process Area	29	AC000	PRO 35	2	279
Industry	Process Area	30	AC000	PRO 35	2	283

COVERAGE	FEATURE TABLE	ID NUMBER	F_CODE	MISSING ITEM*	TILE	PRIM. ID
Industry	Process Area	31	AC000	PRO 21	2	285
Industry	Process Area	32	AC000	PRO 35	2	290
Industry	Process Area	44	AC000	PRO 21	3	22
Industry	Process Area	48	AC000	PRO 74	4	3
Industry	Storage Point	62	AM070	LOC 25	2	108
Industry	Storage Point	63	AM070	USE 25	2	109
Industry	Storage Point	64-72	AM070	LOC 25	2	110-118
Industry	Storage Point	73	AM070	LOC 25	2	133
Industry	Storage Point	74-82	AM070	LOC 25	2	177-185
Industry	Storage Point	84	AM070	LOC 25	2	187
Industry	Storage Point	86-90	AM070	LOC 25	2	189-193
Industry	Storage Point	92-93	AM070	LOC 25	2	195-196
Industry	Storage Point	94-95	AM070	LOC 25	2	198-199
Industry	Storage Point	131	AM070	LOC 25	2	248
Industry	Storage Point	134-138	AM070	LOC 25	3	4-8
Industry	Storage Point	140-154	AM070	LOC 25	4	3-17
Industry	Storage Point	156-161	AM070	LOC 25	4	32-37
Industry	Storage Point	162	AM070	LOC 25	4	39
Industry	Storage Point	164	AM070	LOC 25	4	41
Industry	Storage Point	165	AM070	LOC 25	4	43
Industry	Storage Point	166	AM070	LOC 25	4	48
Industry	Storage Point	167-168	AM070	LOC 25	4	52-53
Industry	Storage Point	169-170	AM070	LOC 25	4	57-58
Industry	Storage Point	182-195	AM070	LOC 25	4	70-83
Industry	Storage Point	203-205	AM070	LOC 25	4	93-95
Industry	Storage Point	206-212	AM070	LOC 25	5	13-19
Industry	Storage Point	227	AM070	LOC 25	5	48
Industry	Storage Point	229-243	AM070	LOC 25	5	50-64

COVERAGE	FEATURE TABLE	ID NUMBER	F_CODE	MISSING ITEM*	TILE	PRIM. ID
Physiography	Embankment Line	2	DB090	USE 8	5	5
Physiography	Embankment Line	3	DB090	USE 8	5	6
Physiography	Embankment Line	4	DB090	USE 8	5	7
Physiography	Embankment Line	5	DB090	USE 8	5	8

*Missing from the product specification, but included in the UV_{Map} Havana database.

Appendix B

Abs	Absolute
CD-ROM	Compact Disc - Read Only Memory
DAFIF	Digital Aeronautical Flight Information File
DFAD	Digital Feature Analysis Data
DMA	Defense Mapping Agency
DMAP	Digital MC&G Analysis Program
DMSO	Defense Modeling and Simulation Office
DQT	Data Quality Table
FACC	Feature and Attribute Coding Catalog
FACS	Feature and Attribute Coding Scheme
FLIP	Flight Information Publication
GIS	Geographic Information System
Hz	Horizontal
IR	Infrared
KVA	Kilovolt-Ampere
MC&G	Mapping, Charting, and Geodesy
MUSE	MC&G Utility Software Environment
NVG	Night Vision Goggles
Rel	Relative
UV_{Map}	Urban Vector Smart Map
Vert	Vertical
VPF	Vector Product Format
VPFVIEW	VPF View (software package)
VPFDUMP	VPF Dump (software for "dumping" tables)